Part V

SUMMARY

AND

CONCLUSIONS

"For the first time in the history of Federal disaster assistance, mitigation - sustained action taken to reduce or eliminate long-term risk to people and their property from hazards and their effects - has become the cornerstone of emergency management."

From **Mitigation: Cornerstone for Building Safer Communities,**
Report of FEMA's Mitigation Directorate for Fiscal year 1995.

Introduction

A primary objective of this report is to provide reference information on what is known and what needs to be done in the area of hazard identification and risk assessment for natural and technological hazards in the United States. A vast amount of knowledge and information is available to characterize many natural and technological hazards, and yet its use may fall short in applications for risk assessment.

One conclusion is that there is a significant need for Federal, State, local, and private entities to work together in applying a national model for risk assessment in order to better use and to prioritize the use of resources. Other significant conclusions include the need for individuals and entities involved in emergency management, risk assessment, and hazard mitigation to focus on the development and implementation of specific actions, including:

- Consistent definitions, characterizations, and detailed information about natural and technological hazards that threaten various regions of the United States and its territories;

- A model risk assessment methodology to assess the potential impacts and exposure of people, key resources, critical facilities, and infrastructure, and for that methodology to be applicable nationally; and

- A uniform technique for quantifying risk and prioritizing the administration of mitigation programs and funding.

CHAPTER

31

SUMMARY AND CONCLUSIONS

SUMMARY

Identification of hazards and assessment of risks affecting the United States and its territories are important steps in the process of reducing the impacts of disasters. These steps help lay the foundation for the judicious allocation of finite resources to support mitigation initiatives. HAZUS, The national risk assessment (loss estimation) methodology under development by FEMA in cooperation with the National Institute for Building Sciences, is intended to achieve this objective.

Based on the hazard identification and risk assessment research and evaluation conducted for this report, the findings include:

- Improvements are needed in the characterization of all hazards because there are inconsistencies in the amount and quality of data available for each hazard;
- Hazards must be better defined because of inconsistencies in definitions used by Federal, State, and local government agencies and private-sector entities involved in evaluating and mitigating hazards;
- A model methodology for risk assessment for all hazards should be established, and the level of sophistication associated with current methodologies should be enhanced;
- A more uniform technique to quantify numerically the risk of each hazard, on an annual-percent-chance exceedance basis, should be developed to allow for a more equitable comparison of risks for multiple hazards;
- The results of risk assessments should serve as the basis for the prioritized administration of mitigation programs and funding; and
- Methods for evaluating the benefits and costs of mitigation programs should be enhanced to include quantitative and qualitative elements.

CONCLUSIONS: NATURAL HAZARDS

Many conclusions can be derived from the investigations and findings of other researchers and agencies. The most significant conclusions are listed below for each category of natural hazard.

Atmospheric

- Associated with the most severe natural catastrophes in U.S. history, hurricanes account for over 67 percent of insured property losses. Hurricane Andrew was the worst disaster in U.S. history, with over $15.5 billion in insured losses and total damage of $25 billion.
- Hurricanes present one of the greatest potentials for substantial loss of life and property because an estimated 36 million people live in the coastal areas that are most exposed. The large influx of people to coastal areas over the past 30 years has resulted in thousands of residents unaware of the hurricane hazard and the flood risks of the coastal high hazard zone. The continued implementation of public education and awareness programs is worthwhile.
- In the immediate shorefront area affected by tropical cyclones, relocation of exposed utility lines, water mains, sewer lines, and roadways has been effective in mitigating damage. Land-use controls and regulatory setback programs in coastal high hazard zones can be difficult because of intense development pressure and high property values.
- The recent deployment of Doppler radar, wind profilers, and networks of automated surface observation systems across the United States will significantly improve understanding of strong winds and can be used to support a nationwide program for mitigating wind-related hazards. Continued modernization and improvement in weather warning systems and implementation of the NEXRAD systems have improved predictions of severe weather phenomena.
- Knowledge about thunderstorms and lightning could be improved, and new research and monitoring are necessary for effective mitigation measures.
- Increased development and other activities in avalanche hazard zones (including winter recreation activities, resort facilities, residences, highways, telecommunication lines, utilities, and mining) have increased the exposure of people and property to snow avalanches.

Geologic

- Current risk assessment methodologies for geologic hazards do not quantify or qualify the frequency of occurrence. An opportunity exists to create a strong national program for hazard identification, risk assessment, and mitigation activities for geologic hazards.

- Geologic hazards generally occur infrequently or slowly over time. As a result, the resources and time expended to address them are not proportionate to the estimated annual damage.

Hydrologic

- In addition to having an impact on traffic, power transmission, and the general population, severe low-pressure systems and winter coastal storms can cause flooding, erosion, and property loss.

- The overwash component of storm surge from coastal storms can cause significant coastal erosion, loss of upland structures and recreational facilities, damage to infrastructure, degradation of water quality, interruption of lifelines and communication networks, injury, and loss of life.

- The severe storms and fluctuating water levels of the Great Lakes have caused hundreds of millions of dollars of erosion and flood damage to shorelines and residential, recreational, and industrial facilities. Episodic events of high lake levels have increased bluff erosion rates and caused the collapse or submergence of structures and beaches.

- Coastal erosion and shoreline change can be a function of multi-year erosion impacts, long-term climatic changes such as sea-level rise, or other natural or human-induced factors that reduce sediment influx, alter littoral processes, influence a shoreline retreat, and threaten large geographic areas and coastal floodplain development.

- Widespread and damaging effects of short- and long-term coastal erosion have had the greatest impact on coastal communities in southern California, Texas, Florida, South Carolina, Maryland, New Jersey, and New York because of intense residential and commercial development.

- National standards do not exist for defining the onset of drought because there are several types of drought and several indices that attempt to characterize them. Development of standards is further complicated by the fact that droughts occur gradually and are characterized by intensity, duration, frequency, and spatial variability.

- Even with adjustment for population and inflation, flood damage is increasing. Approximately 9.6 million U.S. households and property valued at $390 billion are at risk from the 1-percent-annual-chance flood.

- The National Flood Insurance Program has probably been the most dominant positive influence on floodplain management over the past 15 years. However, the majority of buildings exposed to identified flood hazards remain uninsured.

Seismic

- Although the literature indicates significant advancements have been made in most components of earthquake loss estimation, recent regional studies are similar in approach and methodology to studies performed in the 1970s. Application of earthquake loss estimation must be enhanced to match the development of available technology.

- HAZUS, the FEMA/NIBS risk assessment (loss estimation) methodology currently under development provides a standard approach that is user-friendly and utilizes state-of-the-art models for frequency and damage analyses.

- Programs coordinated by FEMA with support from the Building Seismic Safety Council and other agencies have been successful in adopting building codes and regulations to reduce seismic hazards to new and existing buildings. Cooperative programs are a good mechanism for obtaining input from all relevant public and private interests for developing and promulgating regulatory provisions to address earthquake hazard mitigation.

- The processes and trends of recurrent tsunami wave hazards must be understood better before specific, effective mitigation measures can be implemented. The economic impacts of regulatory setback and development-control practices must be evaluated at the national, regional, and local levels.

- Although tsunami events have not been declared disasters in the United States during the past 20 years, the risk to the Pacific Basin coastal zone warrants continued research and investigation.

Volcanic

- Losses resulting from eruptions can be reduced in several ways, including using information on past eruptive activity to define potential for and severity of future eruptions, establishing monitoring systems, and developing and implementing disaster preparedness and emergency evacuation plans.

- Significant improvements have been made in technology for detecting, monitoring, and providing warnings of volcanic eruptions.

- Improved methods are needed to track the movement of ash away from a volcano and to provide information to the airline industry on wind direction and speed around eruptive volcanoes and airborne ash.

Wildfires

- Wildfire mitigation in the urban/wildland interface is primarily the responsibility of homeowners who choose to live is this vulnerable area, and the city and county officials who are responsible for implementing and enforcing emergency management programs and land-use, building, and zoning regulations.

- Historical statistics on the impact of wildfires, including resource and property losses, are available for specific large incidents. Reporting is incomplete, and national statistics are not compiled. Therefore, accurate assessments of the economic impact of wildfires cannot be made.

- Most of the tools, data, and methodologies necessary for an accurate national assessment of the risk posed by wildfires are not yet in place.

CONCLUSIONS: TECHNOLOGICAL HAZARDS

A study of technological hazards is an integral part of the multi-hazard approach to risk assessment. Numerous studies and reports identify and assess the risk of technological hazards. A variety of government agencies and private entities are actively involved in risk assessment and mitigation planning.

This report intentionally focused on the link between natural hazards and technical hazards. Extensive discussion of hazard identification and risk assessment for technological hazards independent of natural hazards is beyond its scope.

For technological hazards that are caused by natural hazards, it is clear that mitigation of natural hazards can minimize the impact of technological hazards. The mitigation procedures and recommendations discussed have important applications for reducing the risk of technological hazards.

CONCLUSIONS: LOSS-REDUCTION OPPORTUNITIES

Many mitigation opportunities are available to reduce losses from natural hazard events. Several categories of opportunities that have been or could be effective are summarized below.

- Zoning as a form of land-use management and control can help regulate populations and residential, commercial, and industrial development in hazard-prone areas. It can be used to control building density, adjust the timing of development plans, and better define "allowable" development. As a first step, maps that identify high-hazard areas should be adopted and used to guide, restrict or limit development. Examples are Flood Insurance Rate Maps used to define floodplains and maps that restrict development in coastal areas.

- Control or protective structures may be useful in protecting life and property in certain circumstances. Examples include levees and dams to control floods and structures to divert or control landslides and snow avalanches.

- Building codes designed to improve construction, reinforcement, and anchoring of buildings and grading codes and practices may be effective in dealing with many hazards. A nationwide hazard-based code may help to ensure implementation of standards appropriate for hazard- and damage-resistant structures. Examples of progress in this area are the recommended provisions for seismic regulations for new and existing buildings that have been developed cooperatively by the Building Seismic Safety Council and FEMA, and land-use zoning measures in the Los Angeles area that reduce losses from landslides.

- Evacuation planning and preparedness programs are helpful in protecting residents in areas subject to imminent danger. Examples of effective programs can be found in areas exposed to tropical cyclones, storm surges, volcanic eruptions, and floods. In general, evacuation saves lives but does not result in significant damage reduction.

- Warnings and forecasts are useful for alerting communities and citizens to an impending hazard event. Both real-time, and longer range forecasts should be provided. Warnings and forecasts are issued in preparation of possible evacuations and to prompt property protection measures. Examples include warnings for floods, debris flows, tropical cyclones, and volcanic eruptions.

- Education and awareness efforts provide hazard information to the public in a non-technical manner to make them aware of the impacts of possible hazards. Informative publications are available for land subsidence, volcanic eruptions, earthquakes, floods, tropical cyclones, and coastal hazards. Information can include, but is not limited to, graphic depictions of hazard areas and evacuation routes, and simple, effective mitigation actions.

- Research on hazard processes and model development are needed to understand hazards and their consequences. This approach has been successful for the development of improved rainfall-runoff models for predicting floods, research on inland wind field models for hurricanes and other tropical cyclones, interdisciplinary research on atmospheric-ocean interrelations, and understanding the processes leading up to volcanic eruptions and earthquakes. Dedicated hazard-specific research facilities could coordinate research efforts with academic institutions and international organizations.

- Monitoring and data collection are necessary to support research, to provide affected communities and citizens with better warnings and forecasts, to understand hazards, and to develop loss reduction methodologies. Examples include the monitoring of coastal water levels, erosion rates, streamflow, and volcanic and seismic activity.

- Buyout, relocation, and demolition of damaged or high risk structures have been effective in reducing exposure of buildings to some hazards, notably flooding, erosion, debris flows, and lava flows.

- Modification of certain hazards may yield benefits. Examples of where people have successfully altered a hazard include detention of floodwaters, triggering snow avalanches, and excavation of expansive soils.

- Relocation of utilities and transportation routes out of extremely high risk areas can be beneficial. Such measures have proven effective in eroding coastal areas and where above-ground utilities have been buried to reduce damage by high wind and severe winterstorms.

- Hazard delineation and mapping are necessary for implementation of land-use controls, zoning, and regulatory setback programs which are effective in dealing with some hazards. Models to identify hazard areas need to be developed or tested to verify accuracy. Hazards that are mapped include floods, lava flows and ashfalls around active volcanoes, snow avalanche paths, earthquake risk zones, landslides, and land subsidence.

- Insurance does not directly reduce physical losses associated with hazards. However, it provides some economic protection through pre-payment and distribution of losses among a wider population. The National Flood Insurance Program is the only program that provides nationwide coverage for flood hazards. Private insurance for other hazards may be available in selected regions, and some States are participating in high risk areas.

- Legislation at all levels of government may be necessary to increase mitigation activity and to promote sound land-use and building practices in hazard-prone areas. Coordinated legislative efforts may support national approaches to the implementation of a model hazard identification and risk assessment methodology for all hazards. Examples that have created effective programs include the statutes for the NFIP and the Earthquake Hazards Reduction Act.

- State, Regional and Federal coordination between and among various agencies and programs encourages loss-reduction opportunities. Specific recommendations have been made for drought mitigation and tropical cyclone evacuation, but other hazards could benefit from coordination as well.

- Enhancement and integration of Federal programs by combination of resources merits consideration. FEMA and other Federal agencies can provide leadership to promote and improve hazard identification and risk assessment programs at the State and local levels.

APPENDIX

A

ACRONYMS AND ABBREVIATIONS

ACRONYMS

AFM	Acoustic Flow Monitor
AIA	American Institute for Architects
ALDS	Automatic Lightning Detection System
AMOL	Atlantic Meteorological and Oceanographic Laboratory
APA	American Planning Association
ASCE	American Society of Civil Engineers
ASDSO	Association of State Dam Safety Officials
ASFPM	Association of State Floodplain Managers
ASOS	Automated Surface Observing System
ATC	Applied Technology Council
ATCF	Automated Tropical Cyclone Forecast (system)
BOCA	Building Officials and Code Administrators
BSSC	Building Seismic Safety Council
CEGS	Code Effectiveness Grading Schedule (for buildings)
CEIS	Coastal Erosion Information System
CERC	Coastal Engineering Research Center
CEI	Composite Exposure Indicator
CRS	Community Rating System
CSEPP	Chemical Stockpile Emergency Preparedness Program
CVI	Coastal Vulnerability Index
DEM	Digital Elevation Model
DFO	Disaster Field Office
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
EAP	Emergency Action Plan
EIS	Emergency Information System
EMI	Emergency Management Institute
EOC	Emergency Operations Center
EPA	Effective Peak Acceleration
EPV	Effective Peak Velocity
EPIX	Emergency Preparedness Information Exchange
EPV	Effective Peak Velocity
EROS	Earth Resources Observation System
ESF	Emergency Support Function

FEMA	Federal Emergency Management Agency
FEMIS	Federal Emergency Management Information System
FERC	Federal Energy Regulatory Commission
FGDC	Federal Geodigital Data Committee
FHWA	Federal Highway Administration
FIA	Federal Insurance Administration
FIDO	Fire Incident Data Organization
FIPS	Federal Information Processing Standard (code)
FRA	Federal Railway Administration
FRERP	Federal Radiological Emergency Response Plan
FRMAC	Federal Radiological Monitoring and Assessment Center
GAO	General Accounting Office
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HAZMAT	Hazardous Material(s)
HCDN	Hydro-Climatic Data Network
HMGP	Hazard Mitigation Grant Program
HMTAP	Hazard Mitigation Technical Assistance Program
IACWD	Interagency Advisory Committee on Water Data
ICBO	International Conference of Building Officials
ICMA	International City/County Management Association
ICODS	Interagency Committee on Dam Safety
ICOLD	International Commission on Large Dams
ICSSC	Interagency Committee on Seismic Safety in Construction
IDNDR	International Decade for Natural Disaster Reduction
IFSAR	Interferometric Synthetic Aperture Radar
IGIS	Integrated Geographic Information System
IILPR	Insurance Institute for Property Loss Reduction
IRC	Insurance Research Council
IWR	Institute for Water Resources
JTWC	Joint Typhoon Warning Center
LIDAR	Light Detection and Ranging (system)
LRM	Loss-Reduction Measure
MIS	Management Information System
MIT	Massachusetts Institute of Technology
MMI	Modified Mercalli Intensity

NAS	National Academy of Sciences
NASA	National Aeronautic and Atmospheric Administration
NBS	National Bureau of Standards
NCDC	National Climatic Data Center
NEHRP	National Earthquake Hazard Reduction Program
NEMA	National Emergency Management Association
NEP	National Earthquake (Loss Reduction) Program
NEPEC	National Earthquake Prediction Evaluation Council
NESEC	New England State Emergency Consortium
NESW	National Earthquake Strategy Working (Group)
NEXRAD	Next Generation Radar (system)
NFDC	National Fire Data Center
NFIC	National Fire Information Council
NFIP	National Flood Insurance Program
NFIRA	National Flood Insurance Reform Act of 1994
NFPA	National Fire Protection Association
NFIRS	National Fire Incident Reporting System
NGDC	National Geophysical Data Center
NHC	National Hurricane Center
NHRAIC	Natural Hazards Research and Applications Information Center
NIBS	National Institute of Building Sciences
NIST	National Institute for Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council or Nuclear Regulatory Commission
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTM	National Technical Means
NWS	National Weather Service
PESH	Potential Earth Science Hazards (module)
PGA	Peak Ground Acceleration
PGD	Permanent Ground Deformation
PGV	Peak Ground Velocity
PI	Plasticity Index
PMEL	Pacific Marine Environmental Laboratory
PPA	Performance Partnership Agreement
PRA	Probabilistic Risk Assessment
PTWC	Pacific Tsunami Warning Center

RAWS	Remote Automatic Weather Station
RERP	Radiological Emergency Response Plan
RSAM	Real-time Seismic Amplitude Measurement (system)
RSPA	Research and Special Programs Administration (DOT)
SAIC	Science Applications International Corporation
SAR	Synthetic Aperture Radar
SBCCI	Southern Building Code Congress International
SCS	U.S. Soil Conservation Service
SHMO	State Hazard Mitigation Officer
SLOSH	Sea Lake and Overland Surge from Hurricane (model)
SSAM	Seismic Spectral Amplitude Measurement
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USCOLD	United States Committee on Large Dams
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFA	U.S. Fire Administration
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USWRC	U.S. Water Resources Council
WERC	Wind Engineering Research Center
WES	Waterways Experiment Station
WIMS	Weather Information Management System

ABBREVIATIONS

C	Celsius
cm	centimeter/centimeters
cm^2	square centimeter/centimeters
cm^3	cubic centimeter/centimeters
F	Fahrenheit
ft	foot/feet
ft/s	feet per second
ft^2	square foot/feet
ft^3	cubic foot/feet
ha	hectare/hectares
in	inch/inches
in^2	square inch/inches
in^3	cubic inch/inches
km	kilometer/kilometers
km/h	kilometers per hour
km^2	square kilometer/kilometers
km^3	cubic kilometer/kilometers
Hz	Hertz
lb/ft^2	pounds per square foot
m	meter/meters
m/s	meters per second
m^2	square meter/meters
m^3	cubic meter/meters
mi	mile/miles
mi^2	square mile/miles
mi^3	cubic mile/miles
mph	miles per hour
MW	megawatt
MWe	megawatt electric
P.L.	Public Law

APPENDIX

B

METRIC CONVERSION TABLE

Length

1 in .... 2.54 cm

1 ft .... 0.3048 m

1 mi .... 1.6093 km

Area

1 in^2 .... 6.452 cm^2

1 ft^2 .... 0.0929 m^2

1 mi^2 .... 2.59 km^2

1 acre .... 0.4047 ha

1 ha .... 10,000 m^2

Volume or capacity

1 in^3 .... 16.39 cm^3

1 ft^3 .... 0.0283 m^3

1 mi^3 .... 4.1682 km^3

1 gal .... 0.13368 ft^3

OR 3.7854 l

1 acre/ft .... 43,560 ft^3

Speed or Velocity

1 ft/s .... 0.3048 m/s

1 mph .... 1.6093 km/h, 0.4470 m/s

PROVIDING COMMENTS ON

MULTI-HAZARD IDENTIFICATION AND RISK ASSESSMENT, A CORNERSTONE OF THE NATIONAL MITIGATION STRATEGY

July, 1997

The information in the report entitled *Multi-Hazard Identification and Risk Assessment, A Cornerstone of the National Mitigation Strategy*, is intended to serve as a baseline summary for natural and technological hazards. It is a reference document for use and enhancement by Federal, State, and local specialists and other users. The report is a living document. FEMA encourages all readers to contribute to its enhancement and expansion for subsequent editions.

If you or your organization would like to share additional hazard-specific or general information, we request that you complete the reverse and submit this sheet (or similar information) along with your contributions to:

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You may contact Ms. Flowers at (202) 646-2748, or Ms. Quinn at (703) 317-6298 if you wish to discuss your comments and concerns.

COMMENT FORM

MULTI-HAZARD IDENTIFICATION AND RISK ASSESSMENT
July, 1997

PLEASE TELL US WHO YOU ARE

Your Name and Title: ______________________________

Name of Organization You Represent: ______________________________

Mailing Address: ______________________________

____

Telephone Number (Optional): ______________________________

FAX/Internet Number (Optional): ______________________________

Date of Comments: ______________________________

Special Area of Interest or Expertise: ______________________________

PLEASE DESCRIBE WHAT YOU ARE PROVIDING

- ☐ Information on a Specific Natural or Technological Hazard(s).
  Please Specify Hazard: ______________________________
- ☐ General Information on Identifying Natural and Technological Hazards
- ☐ Information To Assist in Developing Risk Assessment Methodologies
- ☐ Other. Please Specify: ______________________________

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